

DRAINAGE STUDY

FOR

TPM 21159

**Aqueduct Road
Bonsall, CA 92003**

PREPARED BY:

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PREPARED FOR:

County of San Diego

DATE:

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PROJECT DISCUSSION

A minor subdivision is being processed through the County of San Diego for A.P.N. 127-110-81 where the existing approximately 58 acre site is being subdivided into 4 parcels and a remainder parcel. The majority of the site is undisturbed natural habitat with fairly steep sloping topography. The site is bisected by Aqueduct Road which is constructed along a natural ridgeline, and therefore, the drainage areas west of Aqueduct Road flow in a westerly direction and the drainage areas east of Aqueduct Road flow in a southeasterly direction. The soil types vary between Type B soil east of Aqueduct Road and Type C soil west of Aqueduct Road.

The attached drainage exhibit shows the drainage basins analyzed for this project. The Rational Method, as outlined in the County of San Diego's June, 2003 Hydrology Manual was used to analyze the 100 year flow volumes within the drainage areas. Table 1 on page 2 summarizes the Rational Method analysis. Detailed Rational Method calculations are shown on Page 5.

The project proposes vegetated swales at the locations identified on the drainage exhibit. The vegetated swales will increase the time of concentration for the respective basin and will help decrease the peak post construction runoff volume so that the development of the property does not cause a significant increase in downstream flow volumes.

The BMP data sheets for the proposed vegetated swales are shown on sheets 10 through 14.

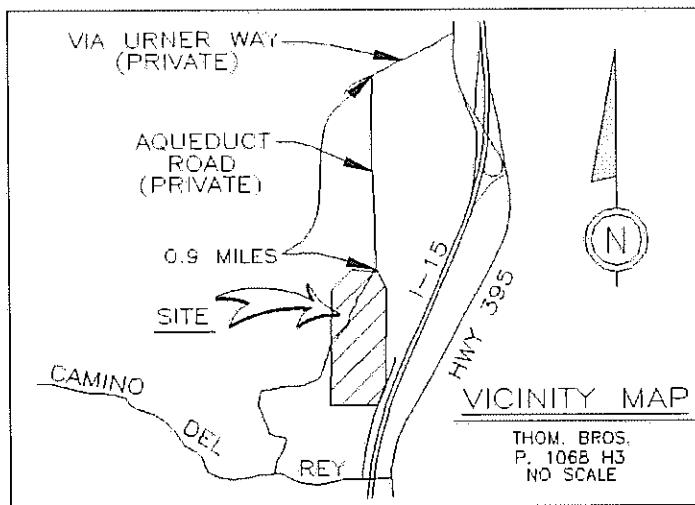
TABLE 1
SUMMARY TABLE
RATIONAL METHOD ANALYSIS
TPM 21159

See attached Drainage Exhibit for acreage, high point/low point, and flow length.

*Rational Method calculation are based on the County of San Diego Hydrology Manual (June, 2003)

*Design storm = 100 year

Area (acres)	Tc (min)	100 yr Q (cfs)	
		Existing	Proposed
Region A			
Subarea A1	19.5	10.7	PT A1
Subarea A2	11.1	11.9	PT A2
With Mitigation (Vegetated Swale)		21.9	
Modified Rational Method for Point A2		10.7	PT A2
			40.7
			33.7
Region B			
	4.7	9.8	PT B
With Mitigation (Vegetated Swale)		19.8	PT B
			7.0
			9.0
Region C			
Subarea C1	5.3	9.0	PT C1
Subarea C2	1.4	8.7	PT C2
With Mitigation (Vegetated Swale)		18.7	
			2.3
			8.3
			2.9
			1.8
Region D			
	8.3	10.0	
With Mitigation (Vegetated Swale)		13.5	
			14.7
			17.6
			14.5

PROJECT VICINITY MAPDECLARATION OF RESPONSIBLE CHARGE

I HEREBY DECLARE THAT I AM THE ENGINEER OF WORK FOR THIS PROJECT. THAT I HAVE EXERCISED RESPONSIBLE CHARGE OVER THE DESIGN OF THE PROJECT AS DEFINED IN SECTION 6703 OF THE BUSINESS AND PROFESSIONALS CODE, AND THAT THE DESIGN IS CONSISTENT WITH CURRENT STANDARDS.

I UNDERSTAND THAT THE CHECK OF PROJECT DRAWINGS AND SPECIFICATIONS BY THE COUNTY OF SAN DIEGO IS CONFINED TO A REVIEW ONLY, AND DOES NOT RELIEVE ME, AS AN ENGINEER OF WORK, OF MY RESPONSIBILITIES FOR PROJECT DESIGN.

4/22/10

SCOTT HARRY, P.E., P.L.S.
R.C.E. 63792

DATE

RATIONAL METHOD CALCULATIONS
TPM 21159

See attached Drainage Exhibit for acreage, high point/low point, and flow length.

*Rational Method calculation are based on the County of San Diego Hydrology Manual procedures (June, 2003)

*Design storm = 100 year

REGION A

AREA A1		Existing				Proposed			
T =	0.1 hours	Area =	19.5 acres	C =	0.25 Soil type B (Undisturbed Natural Terrain)	T =	0.1 hours	Area =	19.5 acres
T =	3.3 min	C =	0.25 Soil type B (Undisturbed Natural Terrain)	L =	1411 feet	T =	3.3 min	C =	0.25 Soil type B (Undisturbed Natural Terrain)
T =	7.4 min	L =	0.27 Miles	Hp =	836	T =	7.4 min	L =	0.27 Miles
T _c =	10.7 min	Hp =		Lp =	420	T _c =	10.7 min	Hp =	
		Lp =		ΔE =	416			Lp =	
		ΔE =		Slope =	29.48%			ΔE =	
		Slope =		I =	5.6 in/hr			Slope =	
		I =	5.6 in/hr	P _g = 3.5 inches				I =	5.6 in/hr
Q = CIA		Q ₁₀₀ =	27.5 cfs	I = (7.44 * 3.5(TC ^{-0.002}))				P _g = 3.5 inches	
		Q = CIA		Q ₁₀₀ =	27.5 cfs				
AREA A2		Existing				Proposed			
T =	0.1 hours	Area =	11.1 acres	C =	0.25 Soil type B (Undisturbed Natural Terrain)	T =	0.1 hours	Area =	11.1 acres
T =	4.5 min	C =	0.25 Soil type B (Undisturbed Natural Terrain)	L =	1885 feet	T =	4.5 min	C =	0.32 Soil type B (1.0 DUA or less)
T =	7.4 min	L =	0.36 Miles	Hp =	780	T =	7.4 min	L =	0.36 Miles
T _c =	11.9 min	Hp =		Lp =	324	T _c =	11.9 min	Hp =	
		Lp =		ΔE =	456			Lp =	
		ΔE =		Slope =	24.19%			ΔE =	
		Slope =		I =	5.3 in/hr			Slope =	
		I =	5.3 in/hr	P _g = 3.5 inches				I =	5.3 in/hr
Q = CIA		Q ₁₀₀ =	14.6 cfs	I = (7.44 * 3.5(TC ^{-0.002}))				P _g = 3.5 inches	
		Q = CIA		Q ₁₀₀ =	14.6 cfs				

Mitigation

The "C" value of 0.32 is high given the development density for this project and therefore the post development "Q" is higher than what would actually occur. However, given that the hydrology manual doesn't have a lower density "C" value option we are still proposing vegetated swales that would mitigate the 4.1 cfs increase.

A 100 foot vegetated swale is proposed at this location which will increase the overall time of concentration as well as the increased limit of concentration due to the pad grading, and flow length. Therefore, with the mitigation the following flow would occur:

$$\begin{aligned}
 T &= 0.1 \text{ hours} & \text{Area} &= 11.1 \text{ acres} \\
 T &= 4.5 \text{ min} & C &= 0.32 \text{ Soil Type B-(1.0 D/u/A or less)} \\
 T_f &= 7.4 \text{ min} & L &= 1885 \text{ feet} \\
 T_c &= 21.9 \text{ min} & H_p &= 0.35 \text{ Miles} \\
 && L_p &= 780 \\
 && \Delta E &= 324 \\
 && \text{Slope} &= 4.56 \\
 && I &= 24.19\%
 \end{aligned}$$

$$I = 3.6 \text{ in/hr} \quad I = (7.44 \cdot 3.5(TC^{0.19}))$$

$$Q = CIA$$

$$Q_{1,ns} = 12.6 \text{ cfs}$$

Modified Rational Method Q at A2

$$\begin{aligned}
 Q_{T1} &= Q_1 + (T_1/T_2)Q_2 \\
 Q_{T2} &= Q_2 + (T_2/T_1)Q_1
 \end{aligned}
 \boxed{\begin{aligned}
 Q_{T1} &= Q_1 + (T_1/T_2)Q_2 \\
 Q_{T2} &= Q_2 + (T_2/T_1)Q_1
 \end{aligned}}$$

$$\begin{aligned}
 Q_1 &= 27.5 & T_1 &= 10.7 & \text{Area A1} &= 11 = 5.6 \\
 Q_2 &= 14.6 & T_2 &= 11.89 & \text{Area A2} &= 12 = 3.6
 \end{aligned}$$

$$\begin{aligned}
 Q_{T1} &= 40.69 \text{ cfs} \\
 Q_{T2} &= 40.36 \text{ cfs}
 \end{aligned}$$

Therefore, use $Q = 40.69$ cfs for Q at this location and $T_c = 10.7$

$$Q = CIA$$

$$Q_{1,ns} = 40.7 \text{ cfs}$$

Modified Rational Method Q at A2

$$\begin{aligned}
 Q_{T1} &= Q_1 + (T_1/T_2)Q_2 \\
 Q_{T2} &= Q_2 + (T_2/T_1)Q_1
 \end{aligned}
 \boxed{\begin{aligned}
 Q_{T1} &= Q_1 + (T_1/T_2)Q_2 \\
 Q_{T2} &= Q_2 + (T_2/T_1)Q_1
 \end{aligned}}$$

$$\begin{aligned}
 Q_1 &= 27.5 & T_1 &= 10.7 & \text{Area A1} &= 11 = 5.6 \\
 Q_2 &= 12.6 & T_2 &= 21.90 & \text{Area A2} &= 12 = 3.6
 \end{aligned}$$

$$\begin{aligned}
 Q_{T1} &= 33.57 \text{ cfs} \\
 Q_{T2} &= 29.97 \text{ cfs}
 \end{aligned}$$

Therefore, use $Q = 33.67$ cfs for Q at this location and $T_c = 10.7$

$$Q = CIA$$

$$Q_{1,ns} = 33.7 \text{ cfs}$$

REGION B

		Existing				Proposed			
T =	0.0 hours	Area =	4.7 acres	C =	0.32 Soil type B-(1.0 Duff/A or less)	T =	0.0 hours	C =	4.7 acres
T =	2.4 min	C =	0.25 Soil type E (Undisturbed Natural Terrain)	L =	936 feet	T =	2.4 min	L =	936 feet
T =	7.4 min	L =	0.18 Miles	Hp =	577	T =	7.4 min	Hp =	577
T _c =	9.8 min	Hp =	0.18 Miles	Lp =	305	T _c =	9.8 min	Lp =	305
T _c =	9.8 min	Lp =	0.18 Miles	ΔE =	272			ΔE =	272
		ΔE =	272	Slope =	29.06%			Slope =	29.06%
I =	6.0 in/hr	I =	{7.44*3.5(TC ^{-0.029})}	P _g =	3.5 inches	I =	6.0 in/hr	I =	{7.44*3.5(TC ^{-0.029})}
Q = CIA		Q = CIA		Q _{1,ro} =	7.0 cfs	Q = CIA		Q _{1,ro} =	9.0 cfs
Q _{1,ro} =	7.0 cfs					Q _{1,ro} =	9.0 cfs		
Mitigation									
The "C" value of 0.22 is high given the development density for this project and therefore the post development "C" is higher than what would actually occur. However, given that the hydrology manual doesn't have a lower density "C" value option we are still proposing vegetated swales that would mitigate the 2.0 cfs increase.									
A 100 foot vegetated swale is proposed for this location which will increase the overall time of concentration as well as the increased time of concentration due to the pad grading. Therefore, with the mitigation the following flow would occur.									
T =	0.0 hours	Area =	4.7 acres	C =	0.32 Soil type B-(1.0 Duff/A or less)	T =	0.0 hours	C =	4.7 acres
T =	2.4 min	C =	0.32 Soil type B-(1.0 Duff/A or less)	L =	936 feet	T =	2.4 min	L =	936 feet
T =	7.4 min	L =	0.18 Miles	Hp =	577	T =	7.4 min	Hp =	577
T _c =	19.8 min	Hp =	0.18 Miles	Lp =	305	T _c =	19.8 min	Lp =	305
T _c =	19.8 min	Lp =	0.18 Miles	ΔE =	272			ΔE =	272
		ΔE =	272	Slope =	29.06%			Slope =	29.06%
I =	3.8 in/hr	I =	{7.44*3.5(TC ^{-0.029})}	P _g =	3.5 inches	I =	3.8 in/hr	P _g =	3.5 inches
Q = CIA		Q = CIA		Q _{1,ro} =	5.7 cfs	Q = CIA		Q _{1,ro} =	5.7 cfs
Q _{1,ro} =	5.7 cfs					Q _{1,ro} =	5.7 cfs		

REGION C

Area C1		Existing		Proposed	
T=	0.0 hours	Area =	5.3 acres	Area =	5.3 acres
T=	1.6 min	C =	0.25 Soil type B (Undisturbed Natural Terrain)	C =	0.25 Soil type B (Undisturbed Natural Terrain)
T _f =	7.4 min	L =	665 feet	L =	665 feet
T _c =	9.0 min	H _p =	627	H _p =	627
		L _p =	350	L _p =	350
		ΔE =	277	ΔE =	277
		Slope% =	41.65%	Slope% =	41.65%
I =	6.3 in/hr	I=(7.44*3.5(TC ^{-0.029}))	P _d = 3.5 inches	I =	I=(7.44*3.5(TC ^{-0.029}))
Q = CIA			P _d = 3.5 inches	Q = CIA	P _d = 3.5 inches
Q _{1,ro} =	8.3 cfs			Q _{1,ro} =	8.3 cfs
Area C2		Existing		Proposed	
T=	0.0 hours	Area =	1.4 acres	Area =	1.4 acres
T=	1.3 min	C =	0.25 Soil type B (Undisturbed Natural Terrain)	C =	0.32 Soil type B-(1.0 DUA or less)
T _f =	7.4 min	L =	264 feet	L =	264 feet
T _c =	8.7 min	H _p =	350	H _p =	350
		L _p =	317	L _p =	317
		ΔE =	33	ΔE =	33
		Slope% =	12.50%	Slope% =	12.50%
I =	6.5 in/hr	I=(7.44*3.5(TC ^{-0.029}))	P _d = 3.5 inches	I =	I=(7.44*3.5(TC ^{-0.029}))
Q = CIA			P _d = 3.5 inches	Q = CIA	P _d = 3.5 inches
Q _{1,ro} =	2.3 cfs			Q _{1,ro} =	2.9 cfs
Mitigation					
A 100 foot vegetated swale is proposed for this location which will increase the overall time of concentration as well as the increased time of concentration due to the pac grading. Therefore, with the mitigation the following flow would occur.					
T=	0.0 hours	Area =	1.4 acres	Area =	1.4 acres
T=	1.3 min	C =	0.32 Soil type B-(1.0 DUA or less)	C =	0.32 Soil type B-(1.0 DUA or less)
T _f =	7.4 min	L =	264 feet	L =	264 feet
T _c =	18.7 min	H _p =	350	H _p =	350
		L _p =	317	L _p =	317
		ΔE =	33	ΔE =	33
		Slope% =	12.50%	Slope% =	12.50%
I =	3.9 in/hr	I=(7.44*3.5(TC ^{-0.029}))	P _d = 3.5 inches	I =	I=(7.44*3.5(TC ^{-0.029}))
Q = CIA			P _d = 3.5 inches	Q = CIA	P _d = 3.5 inches
Q _{1,ro} =	1.8 cfs			Q _{1,ro} =	1.8 cfs

REGION D

	Existing				Proposed			
T=	0.0 hours	Area = 6.3 acres C = 0.30 Soil type C (Undisturbed Natural Terrain)	L = 910 feet T _f = 7.4 min T _e = 10.0 min	H _p = 735 L _p = 565 ΔE = 208 Slope = 22.86%	T= 0.0 hours T = 2.6 min T _f = 7.4 min T _e = 10.0 min	C = 0.36 Soil type C (1.0 DUA or less) L = 910 feet H _p = 735 L _p = 565 ΔE = 208 Slope = 22.86%	Area = 6.3 acres C = 0.36 Soil type C (1.0 DUA or less) L = 910 feet H _p = 735 L _p = 565 ΔE = 208 Slope = 22.86%	P _d = 3.5 inches P _d = 3.5 inches
I=	5.9 in/hr	I=(7.44*3.5(TC ^{0.667}))			I=	5.9 in/hr I=(7.44*3.5(TC ^{0.667}))		
Q = CIA Q ₁₀₀ =	14.7 cfs				Q = CIA Q ₁₀₀ =	17.6 cfs		
Mitigation								
The "C" value of 0.32 is high given the development density for this project and therefore the post development "C" is higher than what would actually occur. However, given that the hydrology manual doesn't have a lower density "C" value option we are still proposing vegetated swales that would mitigate the 2.9 cfs increase.								
A 100 foot vegetated swale is proposed for this location which will increase the overall time of concentration as well as the increased time of concentration due to the pad grading. Therefore, with the mitigation the following flow would occur:								
$T = 0.0 \text{ hours}$ $C = 0.36 \text{ Soil type C (1.0 DUA or less)}$ $L = 910 \text{ feet}$ $H_p = 735$ $L_p = 565$ $\Delta E = 208$ $\text{Slope} = 22.86\%$ $I = 4.9 \text{ in/hr}$ $I=(7.44*3.5(TC0.667))$ $P_d = 3.5 \text{ inches}$ $Q = CIA$ $Q_{100} = 14.5 \text{ cfs}$								

BMP DATA SHEET
RATIONAL METHOD CALCULATIONS
FOR STORM WATER QUALITY VOLUMES Q_{wq}
TPM 21159

Vegetated swales have been selected as the treatment BMP for this project. The vegetated swales have been placed in areas where velocities will be low and runoff from new impervious surfaces will flow directly to the vegetated swales for treatment. The swales were designed per CASQA design standards.

I = 0.2 inches/hr was utilized for the following calculations

AREA A2

$$Q_{85\%}, I = 0.76$$

AREA A2

$$Area = 9.1 \text{ acres}$$

$$\begin{aligned} C &= 0.32 \text{ Soil type B-(1.0 DU/A or less)} \\ L &= 1885 \text{ feet} \\ Hp &= 780 \\ L_p &= 324 \\ \Delta E &= 456 \\ Slope &= 24.19\% \end{aligned}$$

$$I = \frac{1.3 \text{ in/hr}}{2 \text{ in/hr}} = I = (7.44 * 0.76)(T_C^{-0.845})$$

$$\begin{aligned} Q = CIA \\ Q_{wq} = 5.8 \text{ cfs} \end{aligned}$$

Vegetated Swale Capacity

Trapezoidal channel

$$Q = 1.49 / n [A(R^{1/2})(S^{1/2})]$$

Slope =	0.02%	S =	0.02%
Z =	3.00	A =	39
		R =	2.24
		n =	0.25
		Q =	5.6 cfs
		V =	0.14 ft/s

Minimum Residence time = 10 mins, therefore min swale length = 84'
CASCA recommended min = 100'

POINT B

AREA B		$Q_{\text{des}} = 0.76$
$T =$	0.0 hours	Area = 4.7 acres
$T =$	2.4 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 936 feet
$T_c =$	7.4 min	H_p = 577
		L_p = 305
		$\Delta E = 272$
		Slope = 29.06%
$I =$	1.5 in/hr	$I = (7.44 \times 0.76)(T_c^{-0.65})$
	2 in/hr	
$Q = CIA$		
$Q_{\text{wo}} =$	3.0 cfs	

Vegetated Swale Capacity

Trapezoidal channel

$Q = 1.49/nA(R^{2/3})(S^{1/2})$	
b= 3	d= 1.95
wp= 11.7	a= 17.2575
	R= 1.47
	n= 0.25
Slope = 0.050%	S = 0.05%
$Z = 3.00$	A = 17.2575
	R = 1.47
	n = 0.25
$Q = 3.0 \text{ cfs}$	
$V = 0.17 \text{ ft/s}$	

Minimum Residence time = 10 mins, therefore min swale length = 102'

AREA C1

AREA C1		$Q_{85\%}, I = 0.76$
$T =$	0.0 hours	Area = 0.8 acres
$T =$	1.4 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 400 feet
$T_c =$	6.4 min	Hp = 690
		Lp = 605
		$\Delta E = 85$
		Slope = 21.25%
$I =$	1.7 in/hr	$I = (7.44 \times 0.76)(T_c^{-0.045})$
	2.1 in/hr	
$Q = CIA$		
$Q_{100} =$	0.5 cfs	

Vegetated Swale Capacity

Trapezoidal channel		$Q = 1.49/n[A(R^{0.5})(S^{1/2})]$
Slope =	0.03%	$S = 0.03\%$
$z =$	2.00	A = 5.98
		R = 0.77
		$n = 0.25$
		$Q = 0.5 \text{ cfs}$
		$V = 0.09 \text{ ft/s}$

Minimum Residence time = 10 mins, therefore min swale length = 54'
CASQA recommended min = 100'

POINT C2

AREA C2		$Q_{85\%}, I = 0.76$
$T =$	0.0 hours	Area = 1.4 acres
$T =$	1.3 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 264 feet
$T_c =$	6.3 min	Hp = 350
		Lp = 317
		$\Delta E = 33$
		Slope = 12.50%
$I =$	1.7 in/hr	$I = (7.44 \times 0.76)(T_c^{-0.045})$
	2.1 in/hr	
$Q = CIA$		
$Q_{100} =$	0.9 cfs	

Vegetated Swale Capacity

Trapezoidal channel		$Q = 1.49/n[A(R^{0.5})(S^{1/2})]$
Slope =	0.03%	$S = 0.03\%$
$z =$	2.00	A = 9
		R = 0.93
		$n = 0.25$
		$Q = 0.9 \text{ cfs}$
		$V = 0.10 \text{ ft/s}$

Minimum Residence time = 10 mins, therefore min swale length = 60'
CASQA recommended min = 100'

AREA D_House

AREA D		$Q_{65\%}, I = 0.76$
$T =$	0.0 hours	Area = 0.1 acres
$T =$	2.6 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 910 feet
$T_c =$	7.6 min	Hp = 793
		Lp = 585
		$\Delta E = 208$
		Slope = 22.86%
$I =$	1.5 in/hr	$I = (7.44)(0.76)(Tc)^{0.045}$
$Q = CIA$	2 in/hr	
$Q_{100} =$	0.1 cfs	

Vegetated Swale Capacity

AREA D		$Q_{65\%}, I = 0.76$
$T =$	0.0 hours	Area = 0.1 acres
$T =$	2.6 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 0.17 Miles
$T_c =$	7.6 min	Hp = 793
		Lp = 585
		$\Delta E = 208$
		Slope = 22.86%
$I =$	1.5 in/hr	$I = (7.44)(0.76)(Tc)^{0.045}$
$Q = CIA$	2 in/hr	
$Q_{100} =$	0.1 cfs	

$$Q = 1.45[\eta A(R^{m,n})(S^{1/2})]$$

b= 3
d= 1
wp= 7.5
a= 6
R= 0.80

Trapezoidal channel

$$\text{Slope} = 0.03\%$$

$$z = 3.00$$

$$n = 0.25$$

$$Q = 0.5 \text{ cfs}$$

$$V = 0.09 \text{ ft/s}$$

Minimum Residence time = 10 mins, therefore min swale length = 54'
CASQA recommended min = 100'

AREA D_Aqueduct Road

AREA D		$Q_{65\%}, I = 0.76$
$T =$	0.1 hours	Area = 1.5 acres
$T =$	3.6 min	C = 0.32 Soil type B-(1.0 DU/A or less)
$T_i =$	5.0 min	L = 500 feet
$T_c =$	8.6 min	Hp = 795
		Lp = 780
		$\Delta E = 15$
		Slope = 3.00%
$I =$	1.4 in/hr	$I = (7.44)(0.76)(Tc)^{0.045}$
$Q = CIA$	2 in/hr	
$Q_{100} =$	1.0 cfs	

$$Q = 1.45[\eta A(R^{m,n})(S^{1/2})]$$

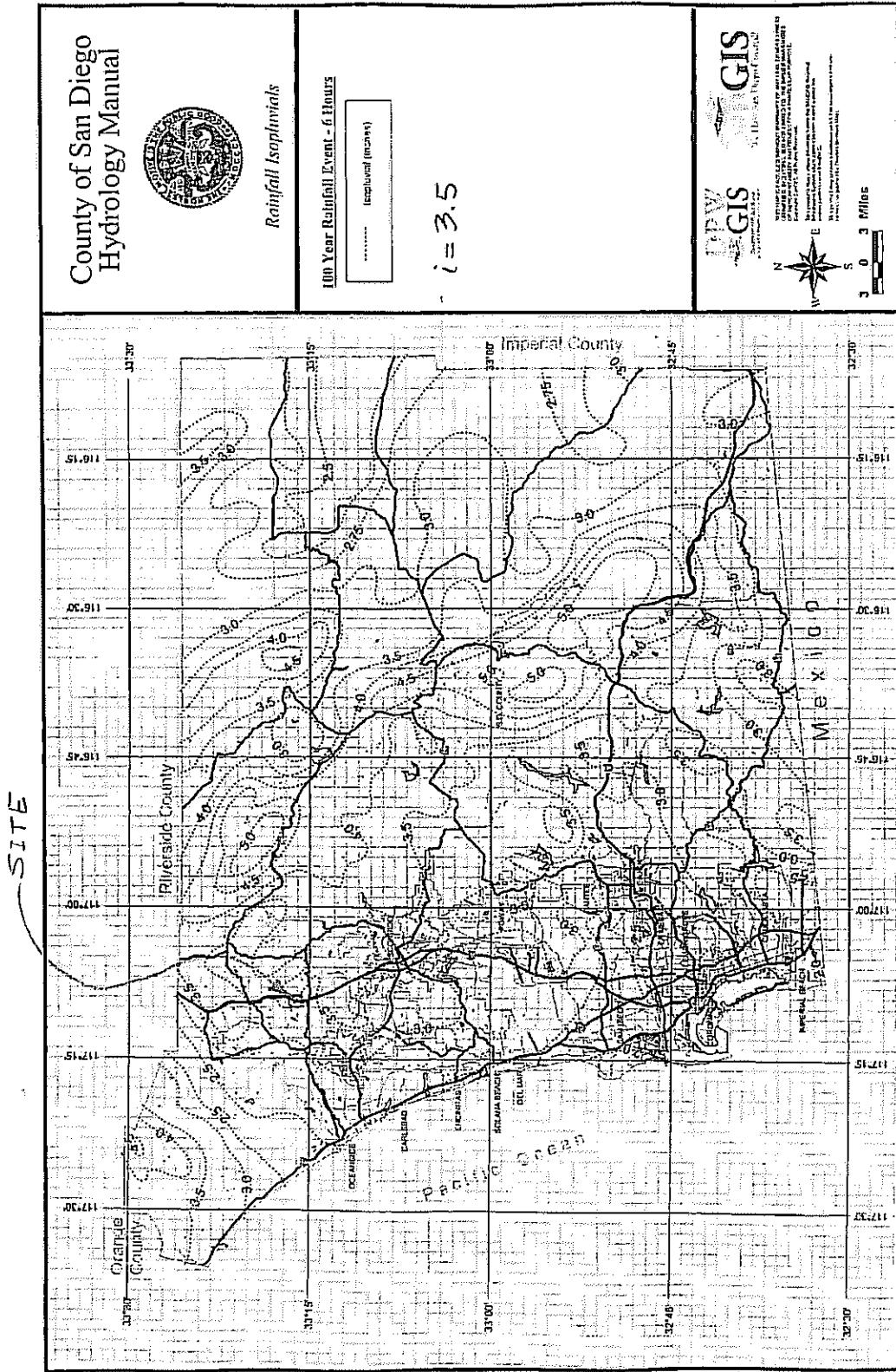
b= 2
d= 1.5
wp= 8.7
a= 9.75
R= 1.12

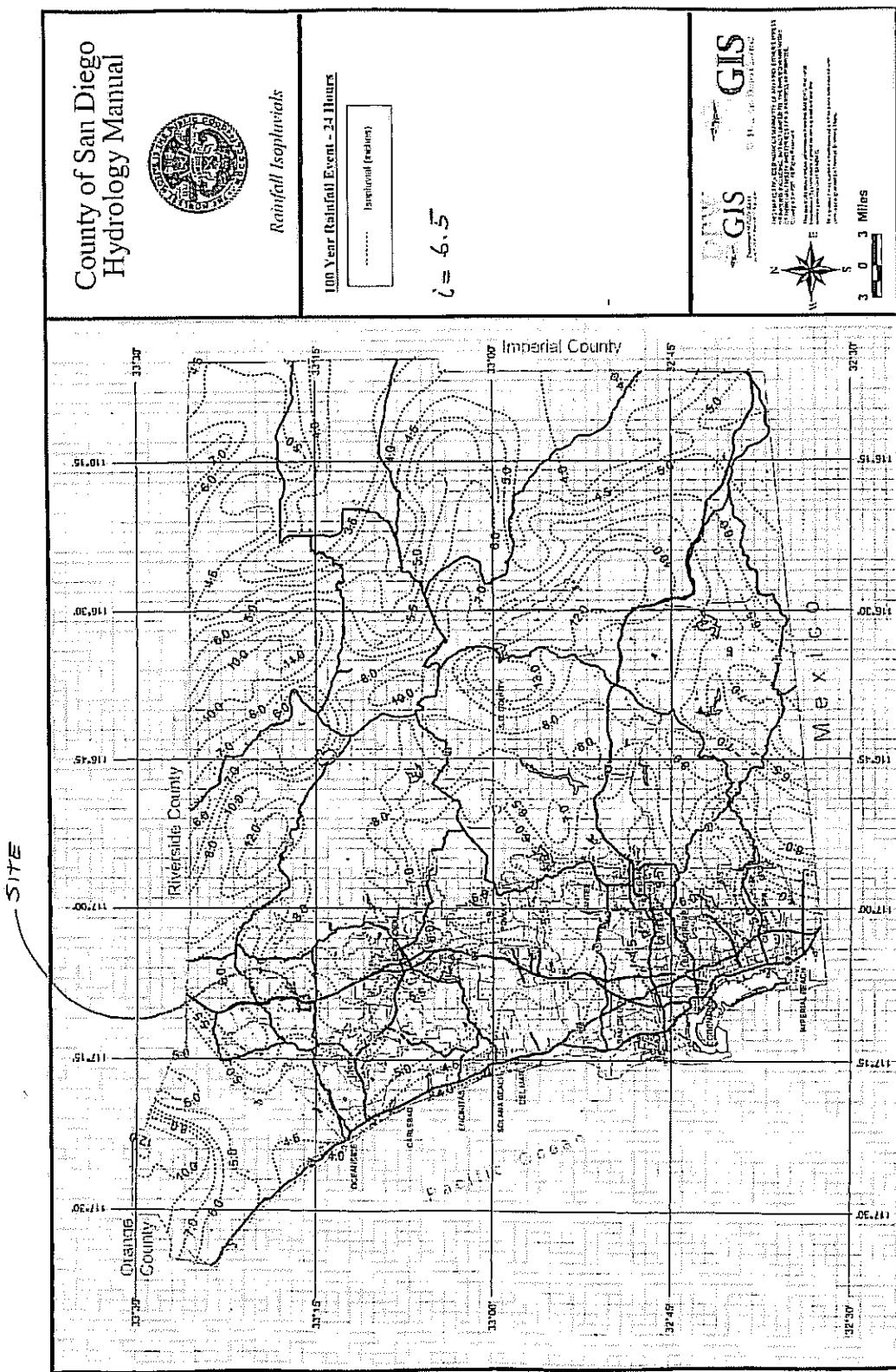
S = 0.03%
A = 9.75
R = 1.12
n = 0.25

$$Q = 1.1 \text{ cfs}$$

$$V = 0.11 \text{ ft/s}$$

Minimum Residence time = 10 mins, therefore min swale length = 66'
CASQA recommended min = 100'





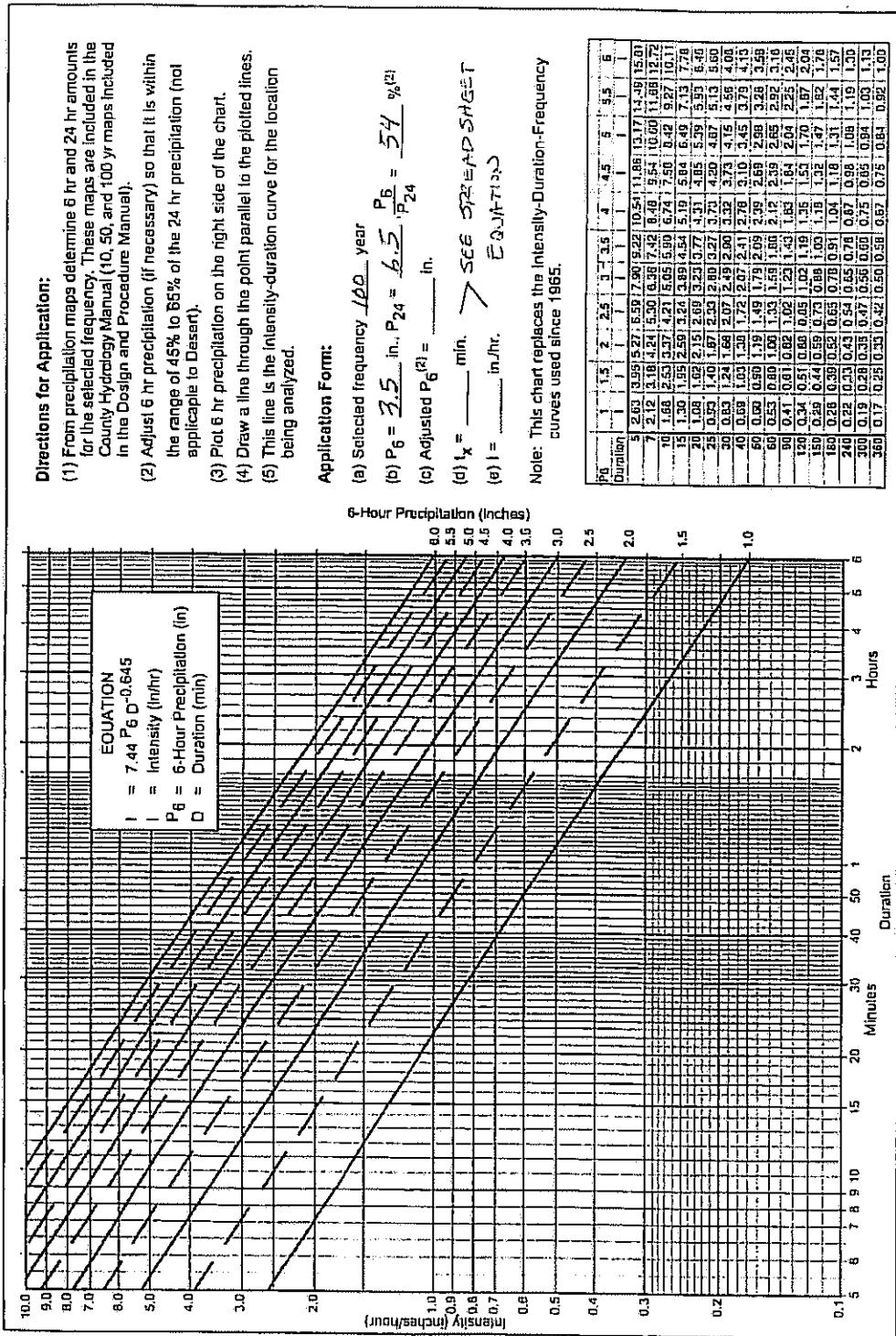


FIGURE
3-1

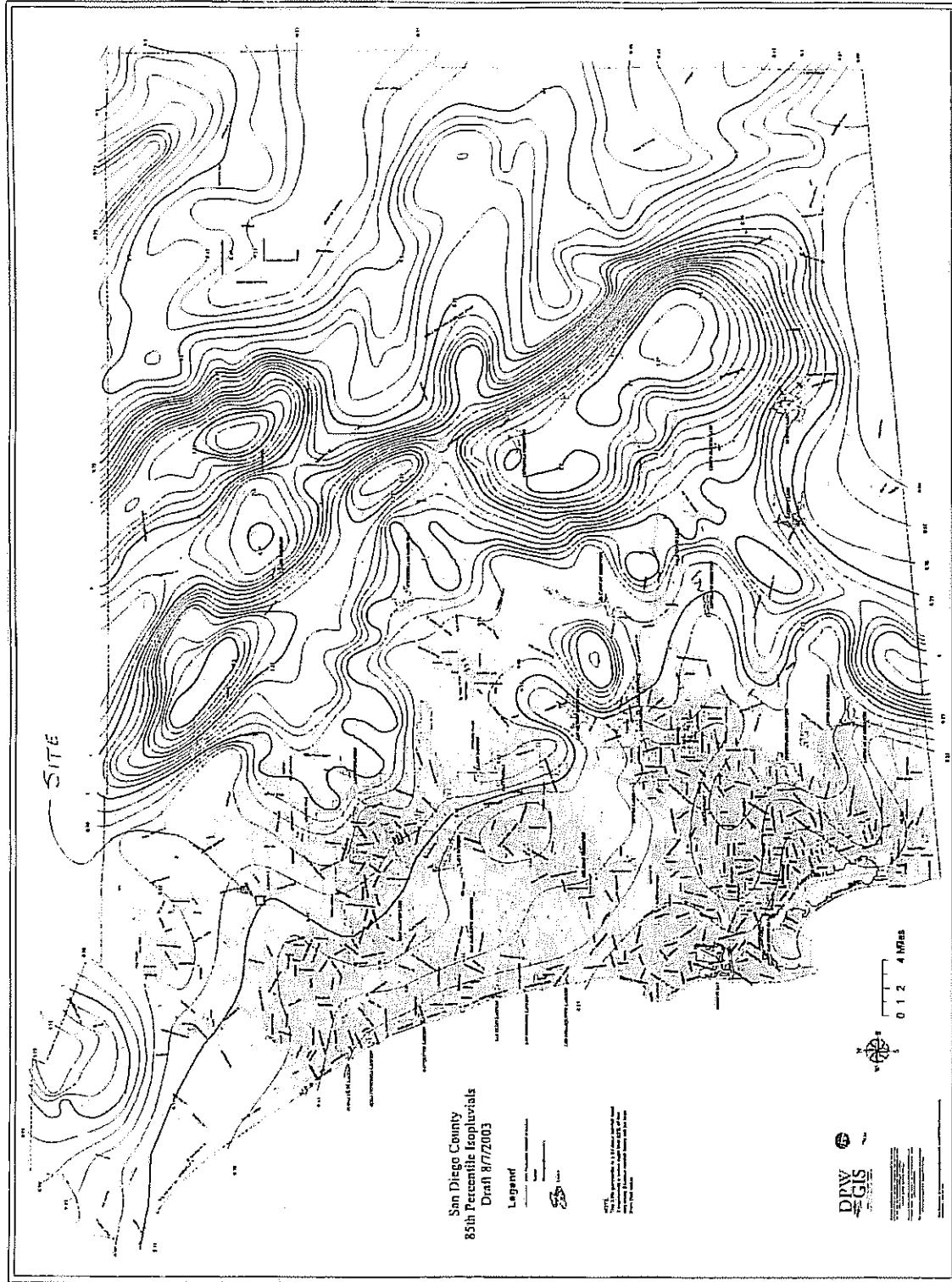


Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

NRCS Elements	Land Use	County Elements	% IMPER.	Runoff Coefficient "C"			
				A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space		0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	(0.32)	0.36	0.41	
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46	
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49	
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52	
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57	
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60	
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63	
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71	
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79	
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79	
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.80	0.81	0.82	
Commercial/Industrial (O.P. Com)	Office Professional/Commercial	90	0.83	0.84	0.84	0.85	
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85	
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87	

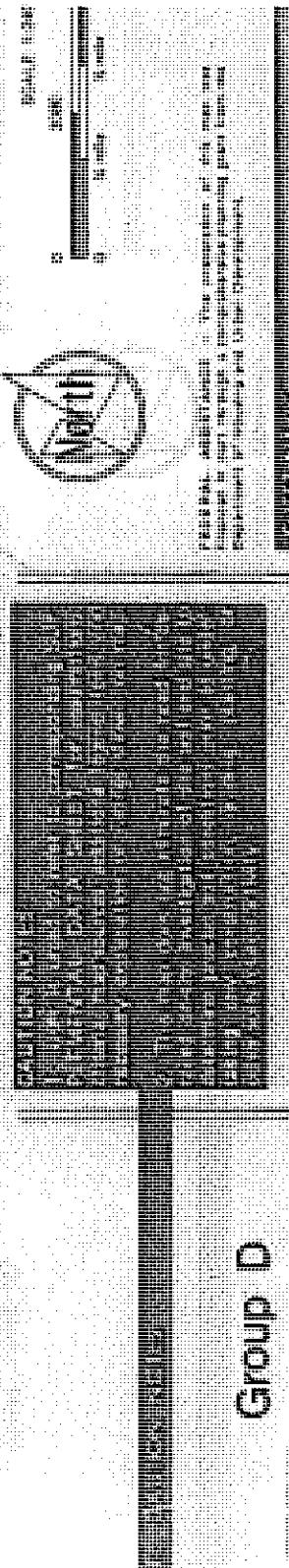
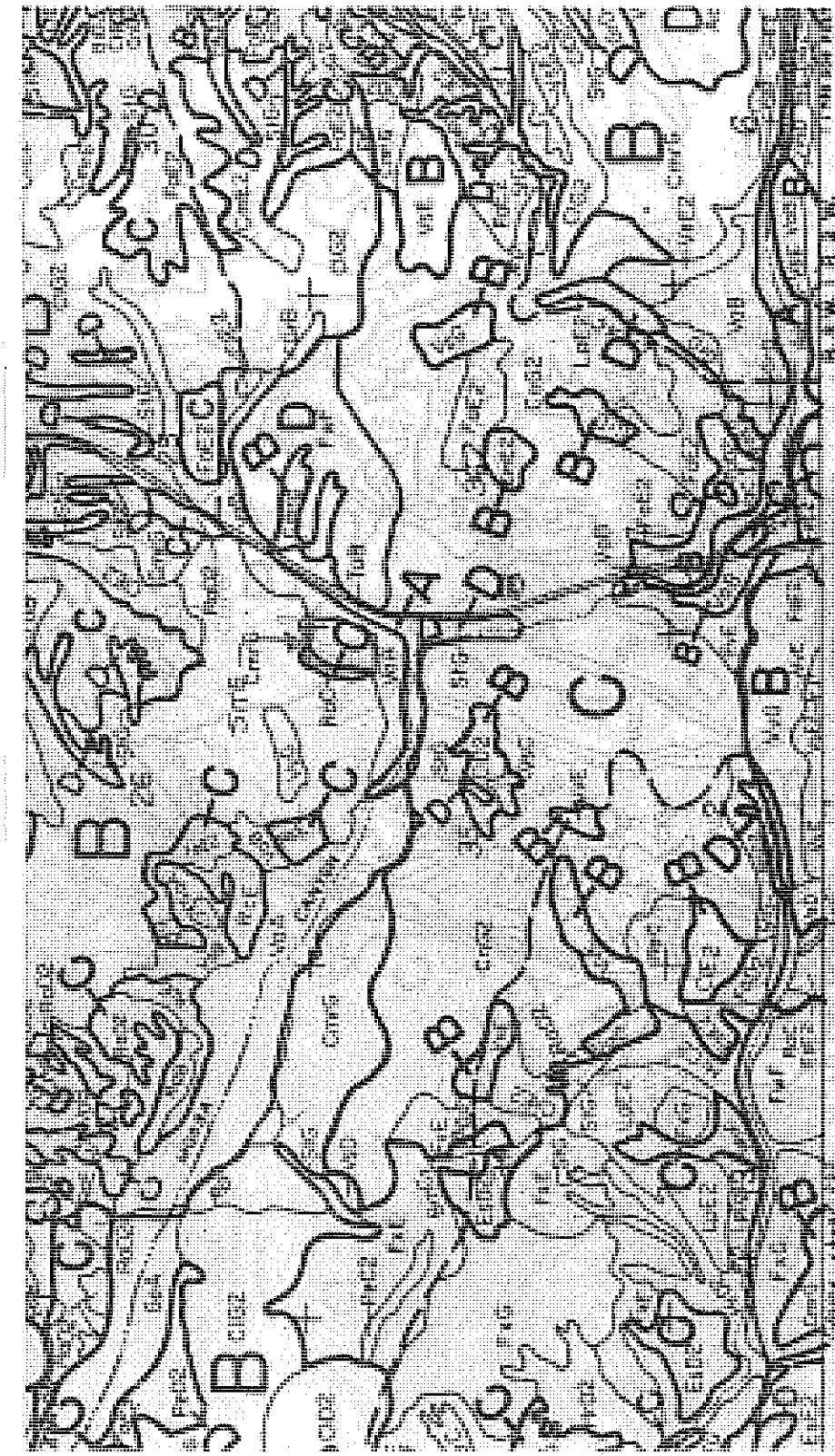
*The values associated with % impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the previous runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).

DU/A = dwelling units per acre

NRCS = National Resources Conservation Service

3-6

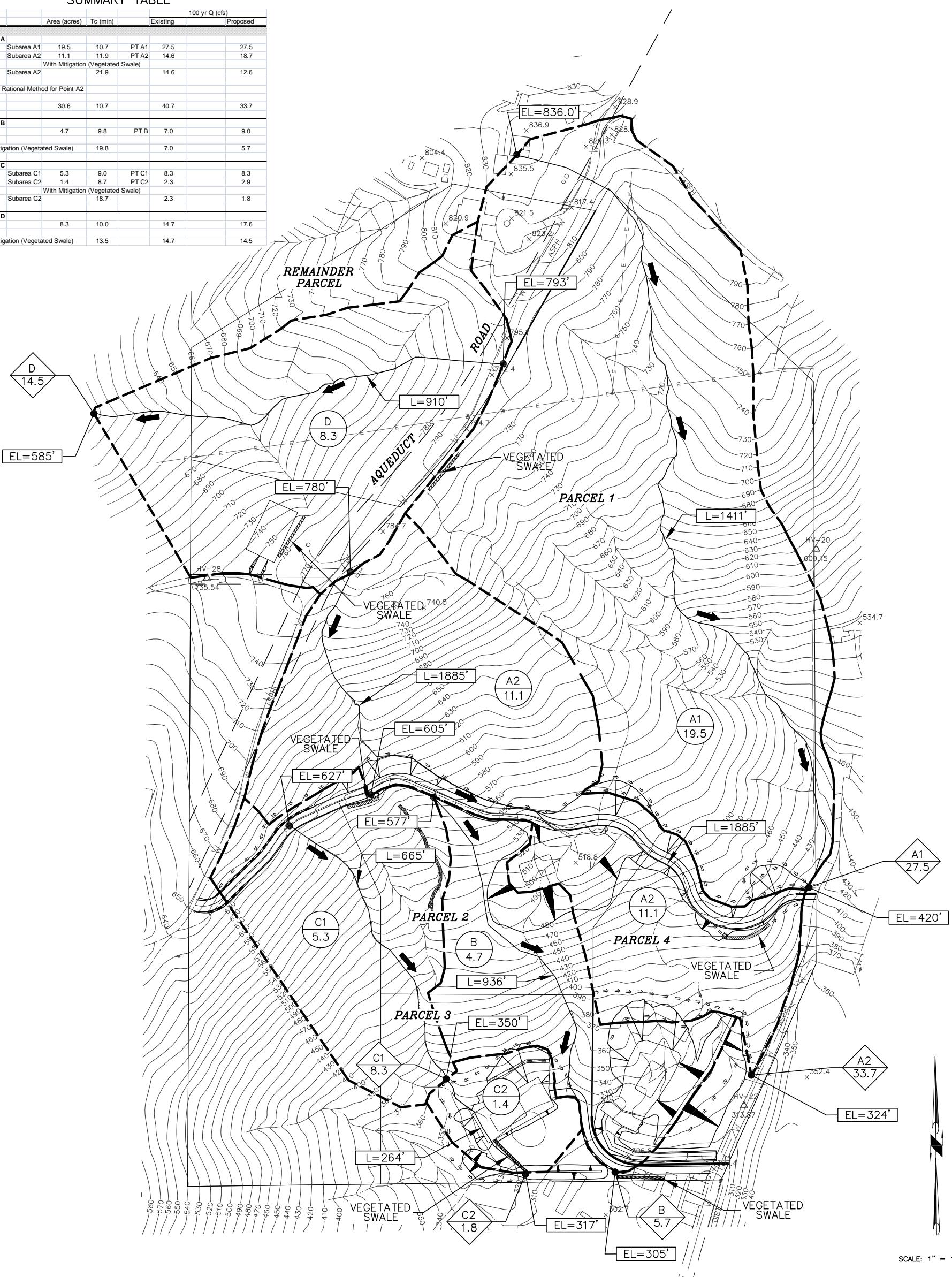
KARN



GROUP D

SUMMARY TABLE

	Area (acres)	Tc (min)	Existing	Proposed
	100 yr Q (cfs)			
Region A				
Subarea A1	19.5	10.7	PT A1	27.5
Subarea A2	11.1	11.9	PT A2	14.6
With Mitigation (Vegetated Swale)				18.7
Subarea A2	21.9		14.6	12.6
Modified Rational Method for Point A2				
	30.6	10.7	40.7	33.7
Region B	4.7	9.8	PT B	7.0
With Mitigation (Vegetated Swale)	19.8		7.0	5.7
Region C				
Subarea C1	5.3	9.0	PT C1	8.3
Subarea C2	1.4	8.7	PT C2	2.3
With Mitigation (Vegetated Swale)				2.9
Subarea C2	18.7		2.3	1.8
Region D	8.3	10.0	14.7	17.6
With Mitigation (Vegetated Swale)	13.5		14.7	14.5



LEGEND

- DRAINAGE BASIN BOUNDARY
- FLOW LINE
- PROPERTY BOUNDARY
- EXISTING/PROPOSED ROADWAY
- VEGETATED SWALE
- REGION DESIGNATION ACREAGE
- POINT OF CONCENTRATION DESIGNATION 100 YR FLOW VOLUME Q(cfs)

DRAINAGE EXHIBIT

TPM 21159
APRIL 20, 2010